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(71) Applicant *(for all designated States except US)*: **THE REGENTS OF THE UNIVERSITY OF CALIFORNIA** [US/US]; UCSD Technology Transfer Office, 9500 Gilman Drive, La Jolla, CA 92093-0910 (US).

(72) Inventors; and

(75) Inventors/Applicants *(for US only)*: **CARSON, Dennis, A.** [US/US]; 9728 Keeneland Row, La Jolla, CA 92037 (US). **TAKABAYASHI, Kenji** [US/US]; 16272 Summer Sage Road, Poway, CA 92064 (US). **COTTAM, Howard, B.** [US/US]; 3144 Willow Creek Place, Escondido, CA 92027 (US). **CHAN, Michael** [US/US]; 3415 Lebon Drvie, #421, San Diego, CA 92122 (US). **WU, Christina, C., N.** [US/US]; 2392 Douglaston Glen, Escondido, CA 92026 (US).

(74) Agents: **CLISE, Timothy, B.** et al.; Schwegman Lundberg Woessner & Kluth, PA, P.O. Box 2938, Minneapolis, MN 55402 (US).

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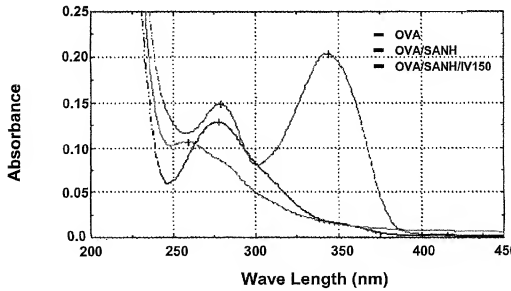
(54) Title: TLR AGONISTS



(57) Abstract: The present invention provides for TLR agonist conjugates (compounds) and compositions, as well as methods of using them. The compounds of the invention are broad-spectrum, long-lasting, and non-toxic combination of synthetic immunostimulatory agents, which are useful for activating the immune system of a mammal, preferably a human and can help direct the pharmacophore to the receptor within the endosomes of target cells and enhance the signal transduction induced by the pharmacophore.

WO 2007/024707 A2

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

TLR AGONISTS

Related Application

This application claims priority from U.S. Provisional Application Serial No. 60/710,337 filed August 22, 2005, which application is herein incorporated by reference.

Government Funding

The invention described herein was made with government support under Grant Number 3 UO1 AI056453-01 awarded by the National Institute of Health. The United States Government has certain rights in the invention.

Background of the Invention

A great deal has been learned about the molecular basis of innate recognition of microbial pathogens in the last decade. It is generally accepted that many somatic cells express a range of pattern recognition receptors that detect potential pathogens independently of the adaptive immune system. (See Janeway et al., Annu Rev Immunol, 20:197-216 (2002).) These receptors are believed to interact with microbial components termed pathogen associated molecular patterns (PAMPs). Examples of PAMPs include peptidoglycans, lipotechoic acids from gram-positive cell walls, the sugar mannose (which is common in microbial carbohydrates but rare in humans), bacterial DNA, double-stranded RNA from viruses, and glucans from fungal cell walls. PAMPs generally meet certain criteria that include, (a) their expression by microbes but not their mammalian hosts, (b) conservation of structure across the wide range of pathogens, and (c) the capacity to stimulate innate immunity. Toll-like Receptors (TLRs) have been found to play a central role in the detection of PAMPs and in the early response to microbial infections. (See Underhill et al., Curr Opin Immunol, 14:103-110 (2002).) Ten mammalian TLRs and a number of their agonists have been identified. For example, TLR7 and TLR9 recognize and respond to imiquimod and immunostimulatory CpG oligonucleotides (ISS-ODN), respectively. The synthetic immunomodulator R-848 (resiquimod)

activates both TLR7 and TLR8. While TLR stimulation initiates a common signaling cascade (involving the adaptor protein MyD88, the transcription factor NF-kB, and pro-inflammatory and effector cytokines), certain cell types tend to produce certain TLRs. For example, TLR7 and TLR9 are found predominantly on the internal faces of endosomes in dendritic cells (DCs) and B lymphocytes (in humans; mouse macrophages express TLR7 and TLR9). TLR8, on the other hand, is found in human blood monocytes. (See Hornung et al., J. Immunol, 168:4531-4537 (2002)).

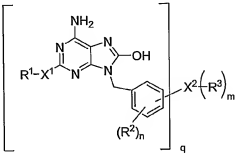
Interferons (INFs) are also involved in the efficient induction of an immune response, especially after viral infection (Brassard et al., J. Leukoc Biol, 71:568-581 (2002).) However, many viruses produce a variety of proteins that block interferon production or action at various levels. Antagonism of interferon is believed to be part of a general strategy to evade innate, as well as adaptive immunity. (See Levy et al., Cytokine Growth Factor Rev, 12:143-156 (2001).) While TLR agonists (TLR-L) may be sufficiently active for some methods of treatment, in some instances the microbial interferon antagonists could mitigate the adjuvant effects of synthetic TLR-L.

Accordingly, there exists a need for compounds that augment TLR-induced signal transduction, i.e., compounds that hinder viral or bacterial obstruction of interferon production or have the ability to modulate the innate immune system using the TLR agonists.

Summary of the Invention

The present invention provides for TLR agonist conjugates (compounds) and compositions, as well as methods of using them. The compounds of the invention are broad-spectrum, long-lasting, and non-toxic combination of synthetic immunostimulatory agents, which are useful for activating the immune system of a mammal, preferably a human and can help direct the pharmacophore to the receptor within the endosomes of target cells and enhance the signal transduction induced by the pharmacophore. The compounds of the invention include a pharmacophore covalently bound to an

auxiliary group. Accordingly there is provided a compound of the invention which is a compound of formula (I):



(I)

wherein X^1 is –O-, -S-, or -NR^c-;

wherein R^c hydrogen, $C_{1\text{-}10}$alkyl, or $C_{1\text{-}10}$alkyl substituted by $C_{3\text{-}6}$-cycloalkyl, or R^c and R^1 taken together with the nitrogen atom can form a heterocyclic ring or a substituted heterocyclic ring, wherein the substituents are hydroxy, $C_{1\text{-}6}$alkyl, hydroxy$C_{1\text{-}6}$alkylene, $C_{1\text{-}6}$alkoxy, $C_{1\text{-}6}$alkoxy$C_{1\text{-}6}$alkylene, or cyano;

R^1 is $(C_1\text{-}C_{10})$alkyl, substituted $(C_1\text{-}C_{10})$alkyl, $C_{6\text{-}10}$aryl, or substituted $C_{6\text{-}10}$aryl, $C_{5\text{-}9}$heterocyclic, substituted $C_{5\text{-}9}$heterocyclic;

each R^2 is independently hydrogen, -OH, $(C_1\text{-}C_6)$alkyl, substituted $(C_1\text{-}C_6)$alkyl, $(C_1\text{-}C_6)$alkoxy, substituted $(C_1\text{-}C_6)$alkoxy, -C(O)-$(C_1\text{-}C_8)$alkyl (alkanoyl), substituted -C(O)-$(C_1\text{-}C_6)$alkyl, -C(O)-$(C_6\text{-}C_{10})$aryl (aroyl), substituted -C(O)-$(C_6\text{-}C_{10})$aryl, -C(O)OH (carboxyl), -C(O)O$(C_1\text{-}C_6)$alkyl (alkoxycarbonyl), substituted -C(O)O$(C_1\text{-}C_6)$alkyl, -NR^aR^b, -C(O)NR^aR^b (carbamoyl), substituted -C(O)NR^aR^b, halo, nitro, or cyano;

each R^a and R^b is independently hydrogen, $(C_1\text{-}C_6)$alkyl, $(C_3\text{-}C_8)$cycloalkyl, $(C_1\text{-}C_6)$alkoxy, halo$(C_1\text{-}C_6)$alkyl, $(C_3\text{-}C_8)$cycloalkyl$(C_1\text{-}C_6)$alkyl, $(C_1\text{-}C_6)$alkanoyl, hydroxy$(C_1\text{-}C_6)$alkyl, aryl, aryl$(C_1\text{-}C_6)$alkyl, Het, Het $(C_1\text{-}C_6)$alkyl, or $(C_1\text{-}C_6)$alkoxycarbonyl;

X^2 is a bond or a linking group; and R^3 is an auxiliary group;

n is 1, 2, 3, or 4; m is 1 or 2; q is 1 or 2; or

a pharmaceutically acceptable salt thereof.

The auxiliary groups can include organic molecules, composed of carbon, oxygen, hydrogen, nitrogen, sulfur, phosphorous atoms. These groups are not harmful to body tissues (*e.g.*, they are non-toxic, and/or do not cause inflammation).

In addition, the invention also provides a pharmaceutical composition comprising at least one compound of formula (I), or a pharmaceutically acceptable salt thereof, in combination with a pharmaceutically acceptable diluent or carrier.

In one embodiment, the invention provides a therapeutic method for preventing or treating a pathological condition or symptom in a mammal, such as a human, wherein the activity of TLR agonists is implicated and its action is desired, comprising administering to a mammal in need of such therapy, an effective amount of a compound of formula (I), or a pharmaceutically acceptable salt thereof. Non-limiting examples of pathological conditions or symptoms that are suitable for treatment include cancers, treatment for bacterial or viral diseases, treating autoimmune diseases, and treating Crohn's Disease.

The compounds of the invention can also be used as or to prepare vaccines against bacteria, viruses, cancer cells, cancer specific peptides, enhancers of monoclonal antibodies against cancer, a CNS stimulant, or for biodefense.

The invention provides a compound of formula (I) for use in medical therapy (*e.g.*, for use as an anti-cancer agent, treatment for bacterial diseases, treatment for viral diseases, such as hepatitis C and hepatitis B, Crohn's Disease, and as therapeutic agents for treating immunologic disease). Furthermore, it is suggested that compounds of formula (I) will prevent carcinogenesis by hepatitis C and hepatitis B, as well as the use of a compound of formula (I) for the manufacture of a medicament useful for the treatment of cancer, viral diseases, Crohn's Disease, and immunologic disorders in a mammal, such as a human.

In a specific embodiment, the present invention provides a method for treating a viral infection in a mammal by administering a TLR agonist compound of formula (I). The viral infection can be caused by an RNA virus, a

product of the RNA virus that acts as a TLR agonist and/or a DNA virus. A specific DNA virus for treatment is the Hepatitis B virus.

In another specific embodiment, the present invention provides a method for treating cancer by administering an effective amount of a TLR agonist compound of formula (I). The cancer can be an interferon sensitive cancer, such as, for example, a leukemia, a lymphoma, a myeloma, a melanoma, or a renal cancer.

In another specific embodiment, the present invention provides a method of treating an autoimmune disease by administering a therapeutically effective amount of a TLR agonist compound of formula (I) or a pharmaceutically acceptable salt of such a compound. A specific autoimmune disease is Multiple Sclerosis, lupus, rheumatoid arthritis and the like.

In another specific embodiment, the present invention provides a method of treating Crohn's Disease by administering a TLR agonist compound of formula (I).

The TLR agonists can be a homofunctional TLR agonist polymer and can consist of a TLR-7 agonist or a TLR-8 agonist. The TLR7 agonist can be a 7-thia-8-oxoguanosinyl (TOG) moiety, a 7-deazaguanosinyl (7DG) moiety, a resiquimod moiety, or an imiquimod moiety. The TLR8 agonist can be a resiquimod moiety. In another aspect, the TLR agonist is a heterofunctional TLR agonist polymer. The heterofunctional TLR agonist polymer can include a TLR-7 agonist and a TLR-8 agonist or a TLR-9 agonist or all three agonists. The heterofunctional TLR agonist polymer can include a TLR-8 agonist and a TLR-9 agonist.

The invention also provides processes and intermediates disclosed herein that are useful for preparing compounds of formula (I) or salts thereof.

Brief Description of the Figures

Figure 1 is a graphic illustration of the absorption chromophore (at ~350 nm) of a compound of formula I (OVA/IV150 Conjugate).

Figure 2 is a graphic illustration of the stimulation of bone marrow derived dendritic cells (BMDC).

Figure 3 illustrates the conjugation of a TLR7 agonist, UC-1V150, to mouse serum albumin (MSA). The success of conjugation is indicated by UV spectroscopy. The UC-1V150 to MSA ratio is approximately 5:1

Figures 4A and B illustrate that the UC-1V150 and MSA conjugates activate both murine bone marrow-derived macrophages (4A) and human peripheral blood mononuclear cells (4B). Cells were incubated with various concentrations of the compound from 0.5 nM to 10 μM in BMDM or from 0.1 to 10 μM in PBMC. Culture supernatants were harvested after 24 h and cytokine levels were analyzed by Luminex.

Figures 5A, 5B, 5C, and 5D illustrate the increased potency and duration of effect of UC-1V150/MSA. C57BL/6 mice were injected (i.v.) with (A) 0.1 micromole of SM-360320, a TLR7 ligand, or (B) equivalent amount of a TLR7 agonist UC-1V150 (aldehyde-modified SM-360320) or UC-1V150/MSA to 500 μg MSA per mouse. Serum samples were collected at the indicated time points and cytokine levels were analyzed by Luminex. MSA = mouse serum albumin. The effect from the original TLR7 ligand, SM-360320, lasted for only 2 hours whereas UC-1V150/MSA has extended the effect to at least 6 hours.

Figure 6 illustrates the effects of UC-1V150 conjugated with inactivated SIV (6A) or with OVA in combination with ODN (6B). Myeloid BMDC were incubated for 24 hr with various conditions at 0.1 μg/ml as indicated. IL-12 levels in the cell supernatant were measured by ELISA.

Figures 7A and 7B illustrates an increased potency of UC-1V150/MSA. C57BL/6 mice were i.v. injected with 380 nmole of SM-360320 or UC-1V150, or 500 μg of UC-1V150/MSA (equivalent to 3.8 nmole UC-1V150) per mouse. Serum samples were collected after 2 h and cytokine levels were analyzed by Luminex. To achieve the similar effect, at least 100-fold higher concentration of either UC-1V150 or SM-360320 was required as compared to that of UC-1V150/MSA.

Figure 8 is an illustration of the uv spectrum of a double-conjugate, (OVA/IV150/1043).

Figure 9 is an illustration of the induction of IL-12 in BMDC using OVA/ODN/IV150 conjugates.

Figure 10 illustrates direct conjugation of SIV Particles to the IA compound IV150.

Figure 11 illustrates the ability to prepare compounds of the invention with virus particles attached to a compound having formula IA and the TLR agonist activity of the compounds.

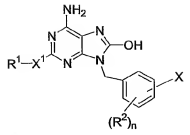
Figure 12 illustrates the molecular areas of specificity for antibodies raised against the conjugates containing a linker and a TLR ligand.

Figures 13A and 13B illustrate the distinction between the four substances applied to the respective lanes on a gel in a Western plot analysis. In Figure 13A , the gel membrane was probed with anti-ovalbumin (anti-OVA) antibody and all lanes gave a positive band, indicating that OVA was detected in all lanes, as expected. In Figure 13B, the gel membrane was probed with the selective antibody raised to the TLR ligand portion of the conjugate, and therefore only lane 4 was positive, confirming the specificity of the antibody for the TLR ligand.

Detailed Description

Non-limiting examples of auxiliary groups include side chains that increase solubility, such as, for example, groups containing morpholino, piperidino, pyrrolidino, or piperazino rings and the like; amino acids, polymers of amino acids (proteins or peptides), *e.g.*, dipeptides or tripeptides, and the like; carbohydrates (polysaccharides), nucleotides such as, for example, PNA, RNA and DNA, and the like; polymers of organic materials, such as, for example, polyethylene glycol, poly-lactide and the like; monomeric and polymeric lipids; insoluble organic nanoparticles; non-toxic body substances such as, for example, cells, lipids, vitamins, co-factors, antigens such as, for example microbes, such as, for example, viruses, bacteria, fungi, and the like. The antigens can include inactivated whole organisms, or sub-components thereof and the like.

The compounds of the invention can be prepared using compounds having formula (IA):



IA

where X is a group that can react to form a bond to the linking group or can react to form a bond to the auxiliary group. A specific group of compounds having formula (IA) are disclosed in U.S. Patent No. 6,329,381.

The following definitions are used, unless otherwise described: halo is fluoro, chloro, bromo, or iodo. Alkyl, alkoxy, alkenyl, alkynyl, etc. denote both straight and branched groups; but reference to an individual radical such as "propyl" embraces only the straight chain radical, a branched chain isomer such as "isopropyl" being specifically referred to. Aryl denotes a phenyl radical or an ortho-fused bicyclic carbocyclic radical having about nine to ten ring atoms in which at least one ring is aromatic. Heteroaryl encompasses a radical attached via a ring carbon of a monocyclic aromatic ring containing five or six ring atoms consisting of carbon and one to four heteroatoms each selected from the group consisting of non-peroxide oxygen, sulfur, and N(X) wherein X is absent or is H, O, (C_1-C_4)alkyl, phenyl or benzyl, as well as a radical of an ortho-fused bicyclic heterocycle of about eight to ten ring atoms derived therefrom, particularly a benz-derivative or one derived by fusing a propylene, trimethylene, or tetramethylene diradical thereto.

It will be appreciated by those skilled in the art that compounds of the invention having a chiral center may exist in and be isolated in optically active and racemic forms. Some compounds may exhibit polymorphism. It is to be understood that the present invention encompasses any racemic, optically-active, polymorphic, or stereoisomeric form, or mixtures thereof, of a compound of the invention, which possess the useful properties described herein, it being well known in the art how to prepare optically active forms (for example, by resolution of the racemic form by recrystallization techniques, by synthesis from optically-active starting materials, by chiral synthesis, or by chromatographic separation using a chiral stationary phase) and how to determine nicotine agonist

activity using the standard tests described herein, or using other similar tests which are well known in the art.

Processes for preparing compounds of formula I or for preparing intermediates useful for preparing compounds of formula I are provided as further embodiments of the invention. Intermediates useful for preparing compounds of formula I are also provided as further embodiments of the invention.

In cases where compounds are sufficiently basic or acidic to form acid or base salts, use of the compounds as salts may be appropriate. Examples of acceptable salts are organic acid addition salts formed with acids which form a physiological acceptable anion, for example, tosylate, methanesulfonate, acetate, citrate, malonate, tartarate, succinate, benzoate, ascorbate, α-ketoglutarate, and α-glycerophosphate. Suitable inorganic salts may also be formed, including hydrochloride, sulfate, nitrate, bicarbonate, and carbonate salts.

Acceptable salts may be obtained using standard procedures well known in the art, for example by reacting a sufficiently basic compound such as an amine with a suitable acid affording a physiologically acceptable anion. Alkali metal (for example, sodium, potassium or lithium) or alkaline earth metal (for example calcium) salts of carboxylic acids can also be made.

Alkyl includes straight or branched C_{1-10} alkyl groups, e.g., methyl, ethyl, propyl, butyl, pentyl, isopropyl, isobutyl, 1-methylpropyl, 3-methylbutyl, hexyl, and the like.

Lower alkyl includes straight or branched C_{1-6} alkyl groups, *e.g.*, methyl, ethyl, propyl, 1-methylethyl, butyl, 1-methylpropyl, 2-methylpropyl, 1,1-dimethylethyl, pentyl, 1-methylbutyl, 2-methylbutyl, 3-methylbutyl, 1,1-dimethylpropyl, 1,2-dimethylpropyl, 2,2-dimethylpropyl, and the like.

The term "alkylene" refers to a divalent straight or branched hydrocarbon chain (*e.g.* ethylene $-CH_2-CH_2-$).

C_{3-7} Cycloalkyl includes groups such as, cyclopropyl, cyclopentyl, cyclohexyl, cycloheptyl, and the like, and alkyl-substituted C_{3-7} cycloalkyl group, preferably straight or branched C_{1-6} alkyl group such as methyl, ethyl,

propyl, butyl or pentyl, and C_{5-7} cycloalkyl group such as, cyclopentyl or cyclohexyl, and the like.

Lower alkoxy includes C_{1-6} alkoxy groups, such as methoxy, ethoxy or propoxy, and the like.

Lower alkanoyl includes C_{1-6} alkanoyl groups, such as formyl, acetyl, propanoyl, butanoyl, pentanoyl or hexanoyl, and the like.

C_{7-11} aroyl, includes groups such as benzoyl or naphthoyl;

Lower alkoxycarbonyl includes C_{2-7} alkoxycarbonyl groups, such as methoxycarbonyl, ethoxycarbonyl or propoxycarbonyl , and the like.

Lower alkylamino group means amino group substituted by C_{1-5} alkyl group, such as, methylamino, ethylamino, propylamino, butylamino, and the like.

Di(lower alkyl)amino group means amino group substituted by the same or different and C_{1-6} alkyl group (e.g. dimethylamino, diethylamino, ethylmethylamino).

Lower alkylcarbamoyl group means carbamoyl group substituted by C_{1-6} alkyl group (e.g. methylcarbamoyl, ethylcarbamoyl, propylcarbamoyl, butylcarbamoyl).

Di(lower alkyl)carbamoyl group means carbamoyl group substituted by the same or different and C_{1-6} alkyl group (e.g. dimethylcarbamoyl, diethylcarbamoyl, ethylmethylcarbamoyl).

Halogen atom means halogen atom such as fluorine atom, chlorine atom, bromine atom or iodine atom.

Aryl refers to a C_{6-10} monocyclic or fused cyclic aryl group, such as phenyl, indenyl, or naphthyl, and the like.

Heterocyclic refers to monocyclic saturated heterocyclic groups, or unsaturated monocyclic or fused heterocyclic group containing at least one heteroatom, *e.g.*, 0-3 nitrogen atoms (-NR^d-), 0-1 oxygen atom (-O-), and 0-1 sulfur atom (-S-). Non-limiting examples of saturated monocyclic heterocyclic group includes 5 or 6 membered saturated heterocyclic group, such as tetrahydrofuranyl, pyrrolidinyl, morpholinyl, piperidyl, piperazinyl or pyrazolidinyl. Non-limiting examples of unsaturated monocyclic heterocyclic group includes 5 or 6 membered unsaturated heterocyclic group, such as furyl, pyrrolyl, pyrazolyl, imidazolyl, thiazolyl, thienyl, pyridyl or pyrimidinyl. Non-

limiting examples of unsaturated fused heterocyclic groups includes unsaturated bicyclic heterocyclic group, such as indolyl, isoindolyl, quinolyl, benzothizolyl, chromanyl, benzofuranyl, and the like.

R^c and R^1 taken together with the nitrogen atom to which they are attached can form a heterocyclic ring. Non-limiting examples of heterocyclic rings include 5 or 6 membered saturated heterocyclic rings, such as 1-pyrrolidinyl, 4-morpholinyl, 1-piperidyl, 1-piperazinyl or 1-pyrazolidinyl, 5 or 6 membered unsaturated heterocyclic rings such as 1-imidazolyl , and the like.

The alkyl, aryl, heterocyclic groups of R^1 can be optionally substituted with one or more substituents, wherein the substituents are the same or different, and include lower alkyl; cycloalkyl, hydroxyl; hydroxy C_{1-6} alkylene , such as hydroxymethyl, 2-hydroxyethyl or 3-hydroxypropyl; lower alkoxy; C_{1-6} alkoxy C_{1-6} alkyl , such as 2-methoxyethyl, 2-ethoxyethyl or 3-methoxypropyl; amino; alkylamino; dialkyl amino; cyano; nitro; acyl; carboxyl; lower alkoxycarbonyl; halogen; mercapto; C_{1-6} alkylthio, such as, methylthio, ethylthio, propylthio or butylthio; substituted C_{1-6} alkylthio, such as methoxyethylthio, methylthioethylthio, hydroxyethylthio or chloroethylthio; aryl; substituted C_{6-10} monocyclic or fused-cyclic aryl, such as 4-hydroxyphenyl, 4-methoxyphenyl, 4-fluorophenyl, 4-chlorophenyl or 3,4-dichlorophenyl; 5-6 membered unsaturated heterocyclic, such as furyl, pyrrolyl, pyrazolyl, imidazolyl, thiazolyl, thienyl, pyridyl or pyrimidinyl; and bicyclic unsaturated heterocyclic, such as indolyl, isoindolyl, quinolyl, benzothiazolyl, chromanyl, benzofuranyl or phthalimino.

The alkyl, aryl, heterocyclic groups of R^2 can be optionally substituted with one or more substituents, wherein the substituents are the same or different, and include hydroxyl; C_{1-6} alkoxy , such as methoxy, ethoxy or propoxy; carboxyl; C_{2-7} alkoxycarbonyl, such as methoxycarbonyl, ethoxycarbonyl or propoxycarbonyl) and halogen.

The alkyl, aryl, heterocyclic groups of R^c can be optionally substituted with one or more substituents, wherein the substituents are the same or different, and include C_{3-6} cycloalkyl; hydroxyl; C_{1-6} alkoxy; amino; cyano; aryl; substituted aryl, such as 4-hydroxyphenyl, 4-methoxyphenyl, 4-chlorophenyl or 3,4-dichlorophenyl; nitro and halogen.

The heterocyclic ring formed together with R^c and R^1 and the nitrogen atom to which they are attached can be optionally substituted with one or more substituents, wherein the substituents are the same or different, and include C_{1-6} alkyl; hydroxy C_{1-6} alkylene; C_{1-6} alkoxy C_{1-6} alkylene; hydroxyl; C_{1-6} alkoxy; and cyano.

The term "amino acid" as used hercin, comprises the residues of the natural amino acids (e.g. Ala, Arg, Asn, Asp, Cys, Glu, Gln, Gly, His, Hyl, Hyp, Ile, Leu, Lys, Met, Phe, Pro, Ser, Thr, Trp, Tyr, and Val) in D or L form, as well as unnatural amino acids (e.g. phosphoserine, phosphothreonine, phosphotyrosine, hydroxyproline, gamma-carboxyglutamate; hippuric acid, octahydroindole-2-carboxylic acid, statine, 1,2,3,4,-tetrahydroisoquinoline-3-carboxylic acid, penicillamine, ornithine, citruline, -methyl-alanine, para-benzoylphenylalanine, phenylglycine, propargylglycine, sarcosine, and tert-butylglycine). The term also comprises natural and unnatural amino acids bearing a conventional amino protecting group (e.g. acetyl or benzyloxycarbonyl), as well as natural and unnatural amino acids protected at the carboxy terminus (e.g. as a (C_1-C_6)alkyl, phenyl or benzyl ester or amide; or as an -methylbenzyl amide). Other suitable amino and carboxy protecting groups are known to those skilled in the art (See for example, T.W. Greene, *Protecting Groups In Organic Synthesis*; Wiley: New York, 1981, and references cited therein). An amino acid can be linked to the remainder of a compound of formula I through the carboxy terminus, the amino terminus, or through any other convenient point of attachment, such as, for example, through the sulfur of cysteine.

The term "toll-like receptor" (TLR) refers to a member of a family of receptors that bind to pathogen associated molecular patterns (PAMPs) and facilitate an immune response in a mammal. Ten mammalian TLRs are known, e.g., TLR1-10.

The term "toll-like receptor agonist" (TLR agonist) refers to a molecule that binds to a TLR and antagonizes the receptor. Synthetic TLR agonists are chemical compounds that are designed to bind to a TLR and activate the receptor. Exemplary novel TLR agonists provided herein include "TLR-7 agonist" "TLR-8 agonist" and "TLR-9 agonist."

The term "nucleic acid" as used herein, refers to DNA, RNA, single-stranded, double-stranded, or more highly aggregated hybridization motifs, and any chemical modifications thereof. Modifications include, but are not limited to, those providing chemical groups that incorporate additional charge, polarizability, hydrogen bonding, electrostatic interaction, and fluxionality to the nucleic acid ligand bases or to the nucleic acid ligand as a whole. Such modifications include, but are not limited to, peptide nucleic acids (PNAs), phosphodiester group modifications (e.g., phosphorothioates, methylphosphonates), 2'-position sugar modifications, 5-position pyrimidine modifications, 7-position purine modifications, 8-position purine modifications, 9-position purine modifications, modifications at exocyclic amines, substitution of 4-thiouridine, substitution of 5-bromo or 5-iodo-uracil; backbone modifications, methylations, unusual base-pairing combinations such as the isobases, isocytidine and isoguanidine and the like. Nucleic acids can also include non-natural bases, such as, for example, nitroindole. Modifications can also include 3' and 5' modifications such as capping with a BHQ, a fluorophore or another moiety.

A specific value for X^1 is a sulfur atom, an oxygen atom or $-NR^c-$.

Another specific X^1 is a sulfur atom.

Another specific X^1 is an oxygen atom.

Another specific X^1 is $-NR^c-$.

Another specific X^1 is –NH-.

A specific value for R^c is hydrogen, C_{1-4} alkyl or substituted C_{1-4} alkyl.

A specific value for R^1 and R^c taken together is when they form a heterocyclic ring or a substituted heterocyclic ring.

Another specific value for R^1 and R^c taken together is substituted or unsubstituted morpholino, piperidino, pyrrolidino, or piperazino ring

A specific value for R^1 is hydrogen, C_{1-4}alkyl, or substituted C_{1-4}alkyl.

Another specific R^1 is 2-hydroxyethyl, 3-hydroxypropyl, 4-hydroxybutyl, 2-aminoethyl, 3-aminopropyl, 4-aminobutyl, methoxymethyl, 2-methoxyethyl, 3-methoxypropyl, ethoxymethyl, 2-ethoxyethyl, methylthiomethyl, 2-methylthioethyl, 3-methylthiopropyl, 2-fluoroethyl, 3-fluoropropyl, 2,2,2-trifluoroethyl, cyanomethyl, 2-cyanoethyl, 3-cyanopropyl, methoxycarbonylmethyl, 2-methoxycarbonylethyl, 3-methoxycarbonylpropyl, benzyl, phenethyl, 4-pyridylmethyl, cyclohexylmethyl, 2-thienylmethyl, 4-methoxyphenylmethyl, 4-hydroxyphenylmethyl, 4-fluorophenylmethyl, or 4-chlorophenylmethyl.

Another specific R^1 is hydrogen, CH_3-, CH_3-CH_2-, $CH_3CH_2CH_2$-, hydroxyC_{1-4}alkylene, or C_{1-4}alkoxyC_{1-4}alkylene.

Another specific value for R^1 is hydrogen, CH_3-, CH_3-CH_2-, CH_3-O-CH_2CH_2- or CH_3-CH_2-O-CH_2CH_2-.

A specific value for R^2 is hydrogen, halogen, or C_{1-4}alkyl.

Another specific value for R^2 is hydrogen, chloro, bromo, CH_3-, or CH_3-CH_2-.

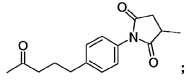
Specific substituents for substitution on the alkyl, aryl or heterocyclic groups are hydroxy, C_{1-6}alkyl, hydroxyC_{1-6}alkylene, C_{1-6}alkoxy, C_{1-6}alkoxyC_{1-6}alkylene, C_{3-6}cycloalkyl, amino, cyano, halogen, or aryl.

A specific value for X^2 is a bond or a chain having up to about 24 atoms; wherein the atoms are selected from the group consisting of carbon, nitrogen, sulfur, non-peroxide oxygen, and phosphorous.

Another specific value for X^2 is a bond or a chain having from about 4 to about 12 atoms.

Another specific value for X^2 is a bond or a chain having from about 6 to about 9 atoms.

Another specific value for X^2 is



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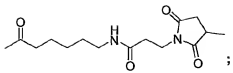
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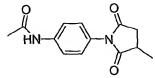
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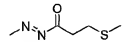
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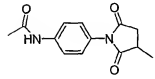
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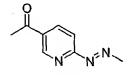
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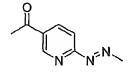
Another specific value for X^2 is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A specific auxiliary group is an amino acid, a carbohydrate, a peptide, an antigen, a nucleic acid, a body substance, or a microbe.

A specific peptide, has from 2 to about 20 amino acid residues.

Another specific peptide, has from 10 to about 20 amino acid residues.

A specific auxiliary group is a carbohydrate.

A specific nucleic acid is DNA, RNA or PNA.

A specific body substance is a cell, lipid, vitamin, or co-factor.

Another specific body substance is a cell or lipid.

A specific antigen is a microbe.

A specific microbe is a virus, bacteria, or fungi.

Another specific microbe is a virus or a bacteria.

Specific bacteria are Bacillus anthracis (anthrax), Listeria monocytogenes, Francisella tularensis, or Salmonella.

Specific Salmonella are typhimurium or enteritidis.

Specific viruses are RNA viruses, a product of the RNA virus, or a DNA virus.

A specific DNA virus is the Hepatitis B virus.

Specific compounds of the invention have the general formula

$IA\text{-}L\text{-}A^1$;

$IA\text{-}L\text{-}(A^1)_2$;

$IA\text{-}L\text{-}A^1\text{-}A^1$;

$IA\text{-}L\text{-}A^1\text{-}L\text{-}A^1$;

$(IA)_2\text{-}L\text{-}A^1\text{-}A^1$;

$(IA)_2\text{-}L\text{-}A^1\text{-}L\text{-}A^1$;

$(IA)_2\text{-}L\text{-}A^1$; or

$(IA)_2\text{-}L\text{-}(A^1)_2$;

wherein IA is as disclosed herein; L is absent or is a linking group; and each A^1 group independently represents an auxiliary group.

In one embodiment, the viral infection is caused by a coronavirus that causes Severe Acute Respiratory Syndrome (SARS), a Hepatitis B virus, or a Hepatitis C Virus.

In another embodiment, the viral infection is caused by a coronavirus that causes Severe Acute Respiratory Syndrome (SARS), a Hepatitis B virus, or a Hepatitis C Virus.

Specific cancers that can be treated include melanoma, superficial bladder cancer, actinic keratoses, intraepithelial neoplasia, and basal cell skin carcinoma, squamous, and the like. In addition, the method of the invention includes treatment for a precancerous condition such as, for example, actinic keratoses or intraepithelial neoplasia, familial polyposis (polyps), cervical

dysplasia, cervical cancers, superficial bladder cancer, and any other cancers associated with infection (*e.g.*, lymphoma Karposi's sarcoma, or leukemia); and the like.

Non limiting examples of the pathological conditions or symptoms that can be treated include viral diseases, cancer, inflammatory diseases of the gastrointestinal tract, brain, skin, joints, and other tissues.

The auxiliary groups are believed to enhance the drug activity of the pharmacophore (compounds of formula (I)) by (a) helping to direct the pharmacophore to the receptor within the endosomes of target cells; (b) by enhancing signal transduction induced by the pharmacophore, by cross-linking the receptor; and/or (c) the pharmacophore can enhance the response to the auxiliary group (*e.g.*, immune response). The auxiliary groups should form generally stable bonds with the pharmacophore, and do not act as prodrugs.

The invention includes compositions of a compound of formula (I) optionally in combination with an inhibitor of inosine monophosphate dehydrogenase (IMPDH), an enantiomer of such a compound, a prodrug of such a compound, or a pharmaceutically acceptable salt of such a compound. As used herein an "IMPDH inhibitor" refers to an inhibitor of the enzyme inosine monophosphate dehydrogenase. Currently, three IMPDH inhibitors are used clinically: ribavirin, mizoribine, and mycophenolate mofetil. Ribavirin and mizoribine are prodrugs that are phosphorylated intracellularly to produce IMP analogs (Goldstein et al., Cuff Med Chem, 6:519-536 (1999)). Viramidine is a prodrug of Ribavirin. Mycophenolate mofetil is immunosuppressive, and has gastrointestinal irritative properties that may be attributable to its enterohepatic recirculation (Papageorgiou C, Mini Rev Med Chem., 1:71-77 (2001)). Mizoribine aglycone, a prodrug, is used as an IMPDH inhibitor. Other non-limiting examples IMPDH inhibitors, including prodrugs of mizoribine and mizoribine aglycone are known and are disclosed in published U.S. Patent application No. 20050004144.

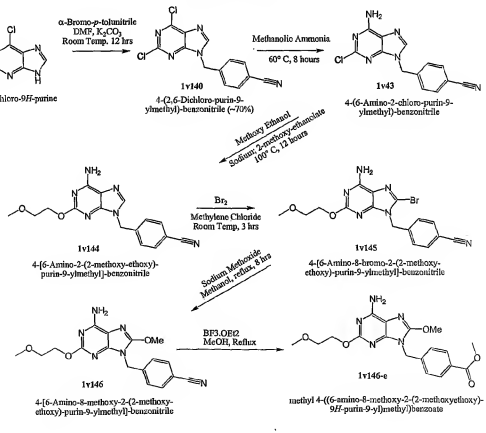
In cases where compounds are sufficiently basic or acidic to form stable nontoxic acid or base salts, administration of the compounds as salts may be appropriate. Examples of pharmaceutically acceptable salts are organic acid addition salts formed with acids which form a physiological acceptable anion,

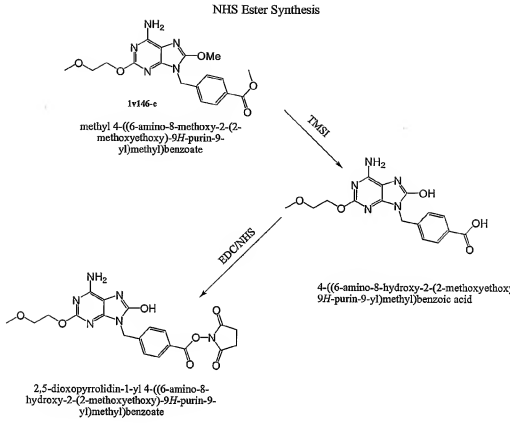
for example, tosylate, methanesulfonate, acetate, citrate, malonate, tartarate, succinate, benzoate, ascorbate, α-ketoglutarate, and α-glycerophosphate. Suitable inorganic salts may also be formed, including hydrochloride, sulfate, nitrate, bicarbonate, and carbonate salts.

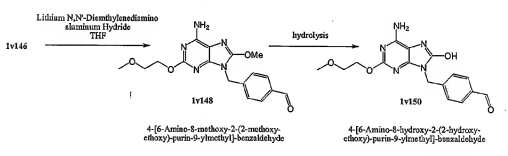
Pharmaceutically acceptable salts may be obtained using standard procedures well known in the art, for example by reacting a sufficiently basic compound such as an amine with a suitable acid affording a physiologically acceptable anion. Alkali metal (for example, sodium, potassium or lithium) or alkaline earth metal (for example calcium) salts of carboxylic acids can also be made.

The compounds (conjugates) of the invention can be prepared using standard synthetic methods known in the art. A general ester synthesis is illustrated below:

General Synthesis







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Additional examples for preparing specific compounds are included herein.

The compounds of formula I can be formulated as pharmaceutical compositions and administered to a mammalian host, such as a human patient in
10 a variety of forms adapted to the chosen route of administration, i.e., orally or parenterally, by intravenous, intramuscular, topical or subcutaneous routes.

Thus, the present compounds may be systemically administered, e.g., orally, in combination with a pharmaceutically acceptable vehicle such as an

inert diluent or an assimilable edible carrier. They may be enclosed in hard or soft shell gelatin capsules, may be compressed into tablets, or may be incorporated directly with the food of the patient's diet. For oral therapeutic administration, the active compound may be combined with one or more excipients and used in the form of ingestible tablets, buccal tablets, troches, capsules, elixirs, suspensions, syrups, wafers, and the like. Such compositions and preparations should contain at least 0.1% of active compound. The percentage of the compositions and preparations may, of course, be varied and may conveniently be between about 2 to about 60% of the weight of a given unit dosage form. The amount of active compound in such therapeutically useful compositions is such that an effective dosage level will be obtained.

The tablets, troches, pills, capsules, and the like may also contain the following: binders such as gum tragacanth, acacia, corn starch or gelatin; excipients such as dicalcium phosphate; a disintegrating agent such as corn starch, potato starch, alginic acid and the like; a lubricant such as magnesium stearate; and a sweetening agent such as sucrose, fructose, lactose or aspartame or a flavoring agent such as peppermint, oil of wintergreen, or cherry flavoring may be added. When the unit dosage form is a capsule, it may contain, in addition to materials of the above type, a liquid carrier, such as a vegetable oil or a polyethylene glycol. Various other materials may be present as coatings or to otherwise modify the physical form of the solid unit dosage form. For instance, tablets, pills, or capsules may be coated with gelatin, wax, shellac or sugar and the like. A syrup or elixir may contain the active compound, sucrose or fructose as a sweetening agent, methyl and propylparabens as preservatives, a dye and flavoring such as cherry or orange flavor. Of course, any material used in preparing any unit dosage form should be pharmaceutically acceptable and substantially non-toxic in the amounts employed. In addition, the active compound may be incorporated into sustained-release preparations and devices.

The active compound may also be administered intravenously or intraperitoneally by infusion or injection. Solutions of the active compound or its salts can be prepared in water, optionally mixed with a nontoxic surfactant. Dispersions can also be prepared in glycerol, liquid polyethylene glycols, triacetin, and mixtures thereof and in oils. Under ordinary conditions of storage

and use, these preparations contain a preservative to prevent the growth of microorganisms.

The pharmaceutical dosage forms suitable for injection or infusion can include sterile aqueous solutions or dispersions or sterile powders comprising the active ingredient which are adapted for the extemporaneous preparation of sterile injectable or infusible solutions or dispersions, optionally encapsulated in liposomes. In all cases, the ultimate dosage form should be sterile, fluid and stable under the conditions of manufacture and storage. The liquid carrier or vehicle can be a solvent or liquid dispersion medium comprising, for example, water, ethanol, a polyol (for example, glycerol, propylene glycol, liquid polyethylene glycols, and the like), vegetable oils, nontoxic glyceryl esters, and suitable mixtures thereof. The proper fluidity can be maintained, for example, by the formation of liposomes, by the maintenance of the required particle size in the case of dispersions or by the use of surfactants. The prevention of the action of microorganisms can be brought about by various antibacterial and antifungal agents, for example, parabens, chlorobutanol, phenol, sorbic acid, thimerosal, and the like. In many cases, it will be preferable to include isotonic agents, for example, sugars, buffers or sodium chloride. Prolonged absorption of the injectable compositions can be brought about by the use in the compositions of agents delaying absorption, for example, aluminum monostearate and gelatin.

Sterile injectable solutions are prepared by incorporating the active compound in the required amount in the appropriate solvent with various of the other ingredients enumerated above, as required, followed by filter sterilization. In the case of sterile powders for the preparation of sterile injectable solutions, the preferred methods of preparation are vacuum drying and the freeze drying techniques, which yield a powder of the active ingredient plus any additional desired ingredient present in the previously sterile-filtered solutions.

For topical administration, the present compounds may be applied in pure form, i.e., when they are liquids. However, it will generally be desirable to administer them to the skin as compositions or formulations, in combination with a dermatologically acceptable carrier, which may be a solid or a liquid.

Useful solid carriers include finely divided solids such as talc, clay, microcrystalline cellulose, silica, alumina and the like. Useful liquid carriers include water, alcohols or glycols or water-alcohol/glycol blends, in which the present compounds can be dissolved or dispersed at effective levels, optionally with the aid of non-toxic surfactants. Adjuvants such as fragrances and additional antimicrobial agents can be added to optimize the properties for a given use. The resultant liquid compositions can be applied from absorbent pads, used to impregnate bandages and other dressings, or sprayed onto the affected area using pump-type or aerosol sprayers.

Thickeners such as synthetic polymers, fatty acids, fatty acid salts and esters, fatty alcohols, modified celluloses or modified mineral materials can also be employed with liquid carriers to form spreadable pastes, gels, ointments, soaps, and the like, for application directly to the skin of the user.

Examples of useful dermatological compositions which can be used to deliver the compounds of formula I to the skin are known to the art; for example, see Jacquet et al. (U.S. Pat. No. 4,608,392), Geria (U.S. Pat. No. 4,992,478), Smith et al. (U.S. Pat. No. 4,559,157) and Wortzman (U.S. Pat. No. 4,820,508).

Useful dosages of the compounds of formula I can be determined by comparing their *in vitro* activity, and *in vivo* activity in animal models. Methods for the extrapolation of effective dosages in mice, and other animals, to humans are known to the art; for example, see U.S. Pat. No. 4,938,949.

Generally, the concentration of the compound(s) of formula I in a liquid composition, such as a lotion, will be from about 0.1-25 wt-%, preferably from about 0.5-10 wt-%. The concentration in a semi-solid or solid composition such as a gel or a powder will be about 0.1-5 wt-%, preferably about 0.5-2.5 wt-%.

The amount of the compound, or an active salt or derivative thereof, required for use in treatment will vary not only with the particular salt selected but also with the route of administration, the nature of the condition being treated and the age and condition of the patient and will be ultimately at the discretion of the attendant physician or clinician.

In general, however, a suitable dose will be in the range of from about 0.5 to about 100 mg/kg, e.g., from about 10 to about 75 mg/kg of body weight per day, such as 3 to about 50 mg per kilogram body weight of the recipient per day, preferably in the range of 6 to 90 mg/kg/day, most preferably in the range of 15 to 60 mg/kg/day.

The compound is conveniently administered in unit dosage form; for example, containing 5 to 1000 mg, conveniently 10 to 750 mg, most conveniently, 50 to 500 mg of active ingredient per unit dosage form.

Ideally, the active ingredient should be administered to achieve peak plasma concentrations of the active compound of from about 0.5 to about 75 μM, preferably, about 1 to 50 μM, most preferably, about 2 to about 30 μM. This may be achieved, for example, by the intravenous injection of a 0.05 to 5% solution of the active ingredient, optionally in saline, or orally administered as a bolus containing about 1-100 mg of the active ingredient. Desirable blood levels may be maintained by continuous infusion to provide about 0.01-5.0 mg/kg/hr or by intermittent infusions containing about 0.4-15 mg/kg of the active ingredient(s).

The desired dose may conveniently be presented in a single dose or as divided doses administered at appropriate intervals, for example, as two, three, four or more sub-doses per day. The sub-dose itself may be further divided, e.g., into a number of discrete loosely spaced administrations; such as multiple inhalations from an insufflator or by application of a plurality of drops into the eye.

The ability of a compound of the invention to act as a TLR agonist may be determined using pharmacological models which are well known to the art, including the procedures disclosed by Lee *et al.*; PNAS, 100 p6646-6651, 2003.

Processes for preparing compounds of formula (I) are provided as further embodiments of the invention and are illustrated by the following procedures in which the meanings of the generic radicals are as given above unless otherwise qualified.

Examples

General Chemistry. Reagents and solvents were acquired from Aldrich, Milwaukee, WI. Uncorrected melting points were determined on a Laboratory Device Mel-Temp II capillary melting point apparatus. Proton nuclear magnetic resonance spectra were recorded on a Varian Unity 500 NMR spectrophotometer at 499.8 MHz or on a Varian Mercury NMR spectrophotometer at 400.06 MHz. The chemical shifts were reported in ppm on the scale from the indicated reference. Positive and negative ion loop mass spectra were performed by Department of Chemistry UCSD, San Diego, CA. Elemental analyses were performed by NuMega Resonance Labs, San Diego, CA. Column chromatography was conducted on E Merck silica gel (230-400 mesh) with the indicated solvent system. Analytical thin layer chromatography (TLC) was conducted on silica gel 60 F-254 plates (EM Reagents).

Example 1 **Preparation of 4-(2,6-dichloropurin-9-ylmethyl)benzonitrile.**

2,6-dichloro-9*H*-purine (16 mmol) is dissolved in DMF (50 mL) and potassium carbonate (50 mmol) is added. α–Bromo-*p*-tolunitrile (22 mmol) is then added and the mixture is stirred at ambient temperature for 16 h. After filtration to remove insoluble inorganic salts, the filtrate is poured into water (1500 mL) and extracted with ethyl acetate (2 x 400 mL), dried over magnesium sulfate and evaporated to yield a residue which is subjected to flash silica gel chromatography using 1:2:10 ethyl acetate/acetone/hexanes. Yield 3.33 g (69%). UV, NMR and MS were consistent with structure assignment.

Example 2 **Preparation of 4-(6-amino-2-chloropurin-9-ylmethylbenzonitrile.**

The product of example 1 (1.9 g) is placed in a steel reaction vessel and methanolic ammonia (80 mL, 7 N) is added. The sealed vessel is heated at 60 °C for 12 h, cooled in ice and the solid product filtered off. Yield 1.09 g. UV, NMR and MS were consistent with assigned structure.

Example 3 **Preparation of 4-[6-amino-2-(2-methoxyethoxy)purin-9-ylmethyl]benzonitrile.**

Sodium salt of 2-methoxyethanol is generated by dissolving sodium metal (81 mg) in 2-methoxyethanol (30 mL) with heat. To this solution is added the product of example 2 (1.0 g) dissolved in methoxyethanol (300 mL, with heat). The reaction mixture is heated for 8 h at 115 °C bath temperature, concentrated in vacuo to near dryness and the residue partitioned between ethyl acetate and water. Flash silica gel chromatography of the organic layer using 5% methanol in dichloromethane gave 763 mg product. NMR is consistent with structure assignment.

Example 4 **Preparation of 4-[6-amino-8-bromo-2-(2-methoxyethoxy)purin-9-ylmethyl]benzonitrile.**

The product of example 3 (700 mg) is dissolved in dichloromethane (400 mL) and bromine (7 mL) is added dropwise. The mixture is stirred overnight at room temperature and extracted with aqueous sodium thiosulfate (2 L of 0.1 M) solution and then with aqueous sodium bicarbonate (500 mL, saturated). The residue from the organic layer is chromatographed on silica gel using 3% methanol in dichloromethane) to yield 460 mg of bromo product. NMR, UV and MS are consistent with structure assignment.

Example 5 **Preparation of 4-[6-amino-8-methoxy-2-(2-methoxyethoxy)purin-9-ylmethyl]benzonitrile.**

Sodium methoxide is generated by reaction of sodium metal (81 mg) in dry methanol (30 mL). The product of example 4 (700 mg) is dissolved in dry dimethoxyethane and the temperature raised to 100 °C. After overnight reaction, the mixture is concentrated in vacuo and the residue is chromatographed on silica using 5% methanol in dichloromethane. Yield 120 mg. NMR is consistent with structure assignment.

Example 6 **Preparation of Lithium N,N'-(dimethylethylenediamino)aluminum hydride.**

This reducing agent used to convert the nitrile to the aldehyde function is prepared essentially as described in *Bull. Korean Chem. Soc.* (2002), **23**(12), 1697-1698. A 0.5 M solution in dry THF is prepared.

Example 7 **Preparation of 4-[6-amino-8-methoxy-2-(2-methoxyethoxy)purin-9-ylmethyl]benzaldehyde.**

The product of example 5 (100 mg) is dissolved in dry THF (3 mL) and cooled to 0 °C under argon. The reagent generated in example 6 (0.72 mL) is added to the reaction flask and the mixture is stirred at 0-5 °C for 1 h and then quenched by addition of 3 *M* HCl. The mixture is then extracted with ethyl acetate and then dichloromethane and concentrated in vacuo to yield 85 mg. NMR is consistent with structure assignment.

Example 8 **Preparation of 4-[6-amino-8-hydroxy-2-(2-methoxyethoxy)purin-9-ylmethyl]benzaldehyde (1V150).**

The product of example 7 (800 mg) is combined with sodium iodide (504 mg) and acetonitrile (40 mL), and then chlorotrimethylsilane (0.5 mL) is slowly added. The mixture is heated at 70 °C for 3.5 h, cooled and filtered. The solid product is washed with water, then ether to yield 406 mg. NMR, UV, MS are consistent with structure assignment. This material is suitable for conjugation reactions between linkers and auxiliary groups.

Example 9 **Preparation of methyl 4-[6-amino-8-methoxy-2-(2-methoxyethoxy)purin-9-ylmethyl]benzoate.** (Procedure as described by Jayachitra, et al., *Synth. Comm.*, (2003) 33(19), 3461-3466.)

The product of example 5 (1 mmol) is dissolved in dry methanol (5 mL) and freshly distilled BF_3 etherate (4 mmol) is added to the solution. The resulting mixture is refluxed under argon for 20 h. The solvent is removed in vacuo and the residue is taken up in dichloromethane (10 mL) and extracted with dilute aqueous sodium bicarbonate (2 x 10 mL) and the organic layer is dried over magnesium sulfate. After evaporation the product is purified by silica gel column chromatography using 5% methanol in dichloromethane to yield 0.8 mmol.

Example 10 **Preparation of 4-[6-amino-8-hydroxy-2-(2-methoxyethoxy)purin-9-ylmethyl]benzoic acid.**

The product of example 9 (100 mg) is combined with sodium iodide (63 mg) and acetonitrile (10 mL), and then chlorotrimethylsilane (120 mL) is slowly added. The mixture is heated at 70 °C for 6 h, cooled and filtered. The solid product is washed with water, then ether to yield 51 mg.

Example 11 **Preparation of 2,5-dioxopyrrolidin-1-yl 4-[6-amino-8-hydroxy-2-(2-methoxyethoxy)purin-9-ylmethyl]benzoate.**

The product of example 10 (2 mmol) is dissolved in dichloromethane or dioxane (10 mL) and EDC (2 mmol) is added. To this solution is added N-hydroxysuccinimide (2 mmol) and resulting mixture is stirred at room temperature for 1 h. The mixture is taken to dryness in vacuo and the crude product is purified by silica gel chromatography to yield 2mmol of product that is suitable for conjugation reactions involving primary amines.

Example 12 **Conjugation of IV150 to mouse serum albumin (MSA)**

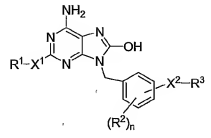
Modification of MSA with SANH: 200µl of MSA (25mg/ml) was mixed with 100µl of conjugation buffer (1M NaPi, pH=7.2) and 690µl of PBS. 844µg of SANH in 10µl of DFM (40-fold molar excess to MSA) was added to protein solution (Final concentration of MSA in reaction mixture is 5mg/ml). After gentle mixing reaction was proceeded at room temperature for 2 hr. To remove excess of SANH the reaction mixture was loaded on NAP-10 column equilibrated with PBS and modified MSA was eluted with 1.5 ml of PBS.

Attachment of IV150 to MSA modified with SANH: 460µg of IV150 dissolved in 10µl of DMF was added to MSA modified with SANH and the reaction mixture was incubated at RT overnight. To remove excess of IV150 the reaction mixture was firstly concentrated to 1 ml using micro-spin column (Millipore: BIOMAX 5K) and loaded on NAP-10 column as mentioned above.

The abbreviations used herein have their conventional meaning within the chemical and biological arts. All publications, patents, and patent documents cited in the specification are incorporated by reference herein, as though individually incorporated by reference. In the case of any inconsistencies, the present disclosure, including any definitions therein will prevail. The invention has been described with reference to various specific and preferred embodiments and techniques. However, it should be understood that many variations and modifications may be made while remaining within the spirit and scope of the invention.

WHAT IS CLAIMED IS:

1. A compound having formula (IA):



(IA)

wherein X^1 is –O-, -S-, or -NR^c-;

wherein R^c is hydrogen, C_{1-10}alkyl, or substituted C_{1-10}alkyl, or R^c and R^1 taken together with the nitrogen atom can form a heterocyclic ring or a substituted heterocyclic ring, wherein the substituents on the alkyl, aryl or heterocyclic groups are hydroxy, C_{1-6}alkyl, hydroxyC_{1-6}alkylene, C_{1-6}alkoxy, C_{3-6}cycloalkyl, C_{1-6}alkoxyC_{1-6}alkylene, amino, cyano, halogen, or aryl;

R^1 is hydrogen, (C_1-C_{10})alkyl, substituted (C_1-C_{10})alkyl, C_{6-10}aryl, or substituted C_{6-10}aryl, C_{5-9}heterocyclic, substituted C_{5-9}heterocyclic; wherein the substituents on the alkyl, aryl or heterocyclic groups are hydroxy, C_{1-6}alkyl, hydroxyC_{1-6}alkylene, C_{1-6}alkoxy, C_{3-6}cycloalkyl, C_{1-6}alkoxyC_{1-6}alkylene, amino, cyano, halogen, or aryl;

each R^2 is independently hydrogen, -OH, (C_1-C_6)alkyl, substituted (C_1-C_6)alkyl, (C_1-C_6)alkoxy, substituted (C_1-C_6)alkoxy, -C(O)-(C_1-C_6)alkyl (alkanoyl), substituted -C(O)-(C_1-C_6)alkyl, -C(O)-(C_6-C_{10})aryl (aroyl), substituted -C(O)-(C_6-C_{10})aryl, -C(O)OH (carboxyl), -C(O)O(C_1-C_6)alkyl (alkoxycarbonyl), substituted -C(O)O(C_1-C_6)alkyl, -NR^aR^b, -C(O)NR^aR^b (carbamoyl), substituted -C(O)NR^aR^b, halo, nitro, or cyano; wherein the substituents on the alkyl, aryl or heterocyclic groups are hydroxy, C_{1-6}alkyl, hydroxyC_{1-6}alkylene, C_{1-6}alkoxy,

C_{3-6}cycloalkyl, C_{1-6}alkoxyC_{1-6}alkylene, amino, cyano, halogen, or aryl;

each R^a and R^b is independently hydrogen, (C_1-C_6)alkyl, (C_3-C_8)cycloalkyl, (C_1-C_6)alkoxy, halo(C_1-C_6)alkyl, (C_3-C_8)cycloalkyl(C_1-C_6)alkyl, (C_1-C_6)alkanoyl, hydroxy(C_1-C_6)alkyl, aryl, aryl(C_1-C_6)alkyl, Het, Het (C_1-C_6)alkyl, or (C_1-C_6)alkoxycarbonyl;

X^2 is a bond or a linking group; and R^3 is an auxiliary group;

or a pharmaceutically acceptable salt thereof.

2. The compound of claim 1, wherein X^1 is sulfur atom.

3. The compound of claim 1, wherein X^1 is oxygen atom.

4. The compound of claim 1, wherein X^1 is -NR^c-, wherein R^c is hydrogen, C_{1-6} alkyl or substituted C_{1-6} alkyl;

wherein the alkyl substituents are C_{3-6}cycloalkyl, hydroxy, C_{1-6}alkoxy, amino, cyano, or aryl.

5. The compound of claim 4, wherein X^1 is –NH-.

6. The compound of any one of claims 1-5, wherein R^1 and R^c taken together form a heterocyclic ring or a substituted heterocyclic ring.

7. The compound of claim 6, wherein R^1 and R^c taken together form a substituted or unsubstituted morpholino, piperidino, pyrrolidino, or piperazino ring.

8. The compound of any one of claims 1-7, wherein R^1 is hydrogen, C_{1-4}alkyl, or substituted C_{1-4}alkyl.

9. The compound of claim 8, wherein R^1 is hydrogen, CH_3-, CH_3-CH_2-, $CH_3CH_2CH_2$-, hydroxyC_{1-4}alkylene, or C_{1-4}alkoxyC_{1-4}alkylene.

10. The compound of claim 9, wherein R^1 is hydrogen, CH_3-, CH_3-CH_2-, CH_3-O-CH_2CH_2- or CH_3-CH_2-O-CH_2CH_2-.

11. The compound of any one of claims 1-10, wherein R^2 is hydrogen, halogen, or C_{1-4}alkyl.

12. The compound of claim 11, wherein R^2 is hydrogen, chloro, bromo, CH_3-, or CH_3-CH_2-.

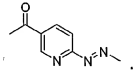
13. The compound of any one of claims 1-12, wherein the substituents on the alkyl, aryl or heterocyclic groups are hydroxy, C_{1-6}alkyl, hydroxyC_{1-6}alkylene, C_{1-6}alkoxy, C_{1-6}alkoxyC_{1-6}alkylene, C_{3-6}cycloalkyl, amino, cyano, halogen, or aryl.

14. The compound of any one of claims 1-13, wherein X^2 is a bond or a chain having up to about 24 atoms; wherein the atoms are selected from the group consisting of carbon, nitrogen, sulfur, non-peroxide oxygen, and phosphorous.

15. The compound of claim 14, wherein X^2 is a bond or a chain having from about 4 to about 12 atoms.

16. The compound of claim 14, wherein X^2 is a bond or a chain having from about 6 to about 9 atoms.

17. The compound of claim 14, wherein X^2 is



18. The compound of any one of claims 1-17, wherein the auxiliary group is an amino acid, a carbohydrate, a peptide, an antigen, a nucleic acid, a body substance, or a microbe.

19. The compound of claim 18, wherein the peptide, has from 2 to about 200 amino acid residues.

20. The compound of claim 19, wherein the peptide, has from 10 to about 200 amino acid residues.

21. The compound of any of claims 1-18, wherein the auxiliary group is a carbohydrate.

22. The compound of claim 18, wherein the nucleic acid is DNA, RNA or PNA.

23. The compound of claim 18, wherein the body substance is a cell, lipid, vitamin, or co-factor.

24. The compound of claim 23, wherein the body substance is a cell, or lipid.

25. The compound of claim 18, wherein the antigen is a microbe.

26. The compound of claim 25, wherein the microbe is a virus, bacteria, parasite, or fungi.

27. The compound of claim 26, wherein the microbe is a virus or a bacteria.

28. The compound of claim 27, wherein the bacteria is Bacillus anthracis (anthrax), Listeria monocytogenes, Francisella tularensis, or Salmonella.

29. The compound of claim 28, wherein the Salmonella is typhimurium or enteritidis.

30. The compound of claim 26, wherein the virus is an RNA virus, a product of the RNA virus, or a DNA virus.

31. The compound of claim 30, wherein the DNA virus is the Hepatitis B virus.

32. A pharmaceutical composition comprising a compound of any one of claims 1-31, and a pharmaceutically acceptable carrier.

33. A therapeutic method for preventing or treating a pathological condition or symptom in a mammal, wherein the activity of TLR receptors is implicated and agonism of such activity is desired, comprising administering to a mammal in need of such therapy, an effective amount of a compound of any of claims 1-31.

34. The method of claim 33, wherein the condition or symptom is cancer, bacterial disease, viral disease, autoimmune disease, or Crohn's Disease.

35. The method of claim 34, wherein the bacteria is Bacillus anthracis (anthrax), Listeria monocytogenes, Francisella tularensis, or Salmonella.

36. The method of claim 35, wherein the Salmonella is typhimurium or enteritidis.

37. The method of claim 34, wherein the virus is an RNA virus, a product of the RNA virus, or a DNA virus.

38. The method of claim 37, wherein the DNA virus is the Hepatitis B virus.

39. The method of claim 34, wherein cancer can be an interferon sensitive cancer, such as, for example, a leukemia, a lymphoma, a myeloma, a melanoma, or a renal cancer.

40. A compound of any one of claims 1-31, for use in medical therapy.

41. The use of claim 40, wherein the medical therapy is treating cancer, bacterial disease, viral disease, autoimmune disease, or Crohn's Disease.

42. Use of a compound of any one of claims 1-31 to prepare a medicament for treating cancer, bacterial disease, viral disease, autoimmune disease, or Crohn's Disease.

43. Use of claim 42, wherein the medicament includes a physiologically acceptable carrier.

Fig. 1

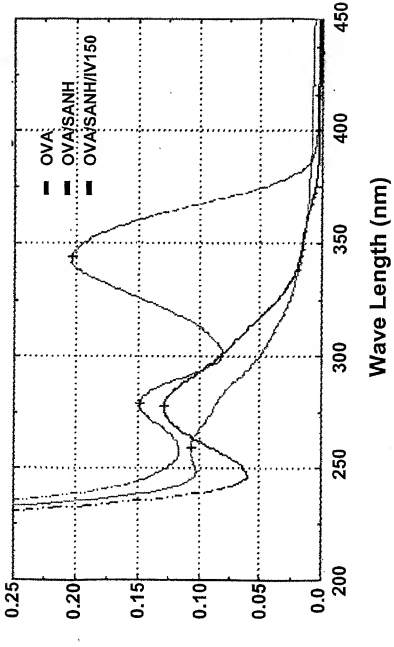

OVA
OVA/SANH
OVA/SANH/IV150
Absorbance
0.25
0.20
0.15
0.10
0.05
0.0
200
250
300
350
400
450
Wave Length (nm)

Fig. 2

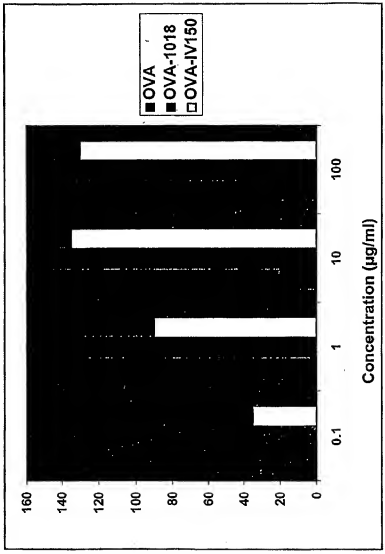

OVA
OVA-1018
OVA-IV150
160
140
120
100
80
60
40
20
0
0.1
1
10
100
Concentration (µg/ml)

Fig. 3

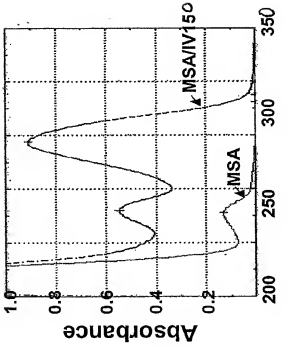


Fig. 4A

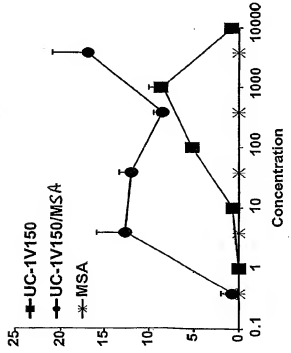
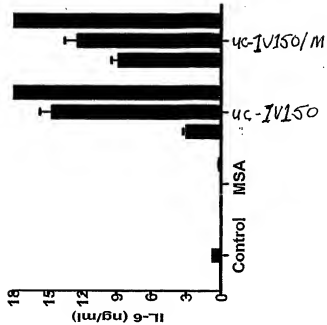

UC-1V150
UC-1V150/MSA
MSA
25
20
15
10
5
0
0.1
1
10
100
1000
10000
Concentration

Fig. 4B


IL-6 (ng/ml)
18
15
12
9
6
3
0
Control
MSA
uc-IV150
uc-IV150/MSA

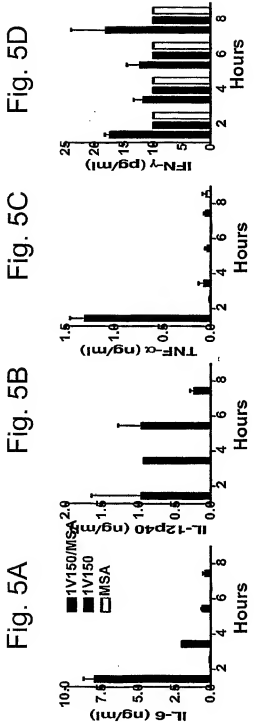


Fig. 5A
IL-6 (ng/ml)
10.0
7.5
5.0
2.5
0.0
1V150/MSA
1V150
MSA
0
2
4
6
8
Hours
Fig. 5B
IL-12p40 (ng/ml)
2.0
1.5
1.0
0.5
0.0
0
2
4
6
8
Hours
Fig. 5C
TNF-α (ng/ml)
1.5
1.0
0.5
0.0
0
2
4
6
8
Hours
Fig. 5D
IFN-γ (pg/ml)
25
20
15
10
5
0
0
2
4
6
8
Hours

Fig. 6B

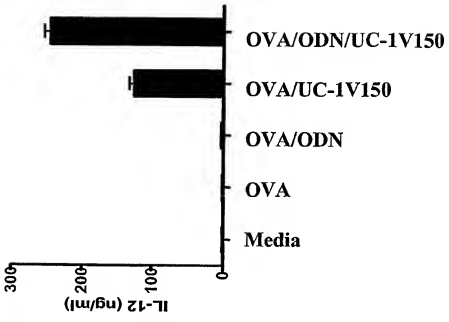

OVA/ODN/UC-1V150
OVA/UC-1V150
OVA/ODN
OVA
Media
IL-12 (ng/ml)
0
100
200
300

Fig. 6A

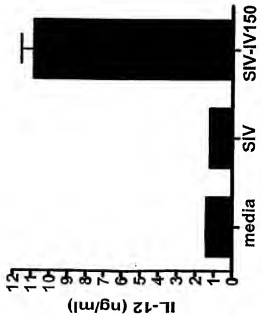

SIV-IV150
SIV
media
IL-12 (ng/ml)
0
1
2
3
4
5
6
7
8
9
10
11
12

Fig. 7A

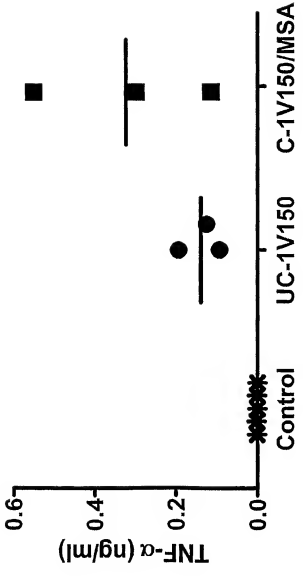


Fig. 7B

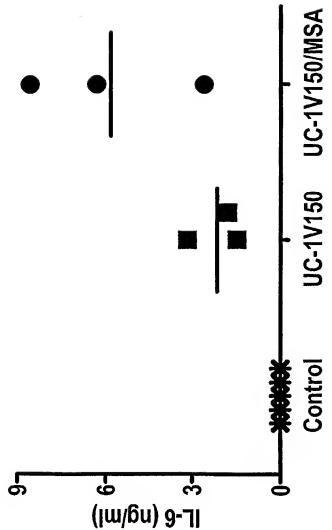


Fig. 8

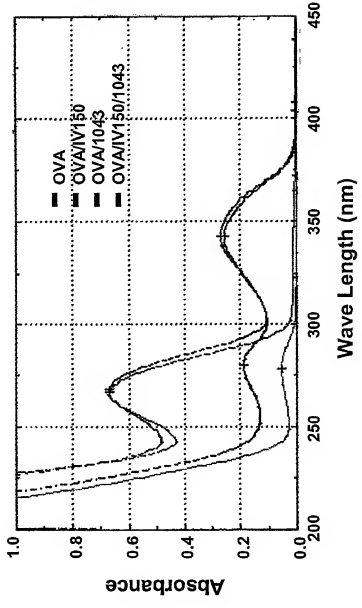

OVA
OVA/IV150
OVA/1043
OVA/IV150/1043
Absorbance
1.0
0.8
0.6
0.4
0.2
0.0
200
250
300
350
400
450
Wave Length (nm)

Fig. 9
Induction of IL-12 in BMDC

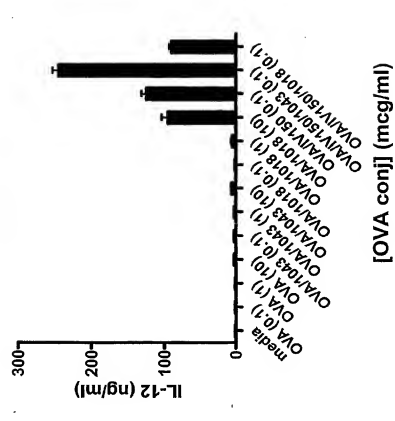


Fig. 10

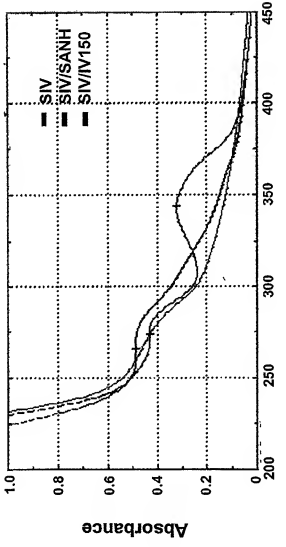

SIV
SIV/SANH
SIV/IV150
Absorbance
Wave Length (nm)
1.0
0.8
0.6
0.4
0.2
0
200
250
300
350
400
450

Fig. 11

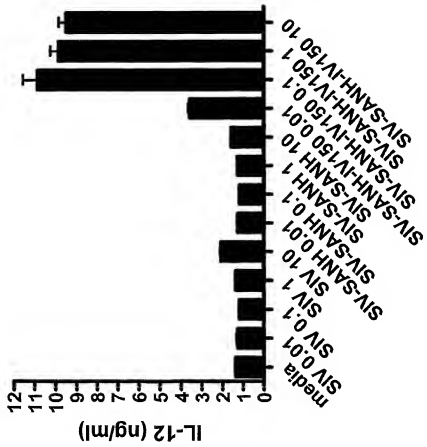

BMDC IL-12
IL-12 (ng/ml)
0
1
2
3
4
5
6
7
8
9
10
11
12
media
SIV 0.01
SIV 0.1
SIV 1
SIV 10
SIV-SAnH 0.01
SIV-SAnH 0.1
SIV-SAnH 1
SIV-SAnH 10
SIV-SAnH-JV150 0.01
SIV-SAnH-JV150 0.1
SIV-SAnH-JV150 1
SIV-SAnH-JV150 10

Fig. 12

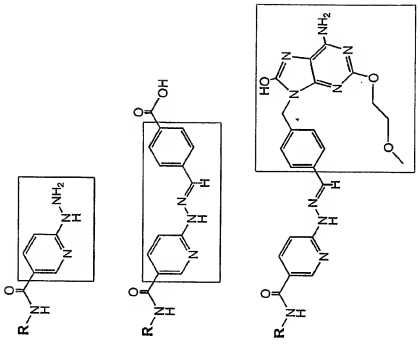
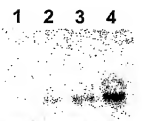
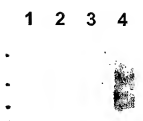


Fig. 13A



Anti-OVA

Fig. 13B



Anti-IV150

1: OVA
2: OVA/SANH
3: OVA/SANH/SFB
4: OVA/SANH/IV150